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in

Delgado I. (ed.), Lloveras J. (ed.).
Quality in lucerne and medics for animal production

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 45

2001
pages 25-27

Breeding of the alfalfa plant morphology for quality

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SUMMARY – Quality (protein and fiber contents) in alfalfa are mainly influenced by leaf to stem ratio. In order to maximise this ratio at Lodi Institute we have followed different ways: (i) tolerance to early cutting (blue bud stage); (ii) modification of stem morphology towards maximum height and shorter internodes; and (iii) high growth rate associated to a delay of the reproductive phase. Consequently, three plant models have been defined for the different breeding strategies; data from the three approaches to vigour and quality improvement are presented.

Key words: Early cutting, stem morphology, rate of development.

RESUME – *"Amélioration de la morphologie de la plante chez la luzerne pour la qualité". Le rapport feuilles/tiges est le principal facteur influençant la qualité (teneur en fibres et protéines) de la luzerne. Pour optimiser ce rapport on a suivi à l'Institut de Lodi différentes voies : (i) résistance à la coupe précoce (stade bouton bleu) ; (ii) modification de la morphologie des tiges vers la réduction de la longueur des entre-noeuds en gardant la hauteur maximale ; et (iii) taux de croissance élevé associé à une floraison tardive. Par conséquent, trois modèles de plante ont été définis pour les différentes stratégies d'amélioration ; des données relatives aux trois voies sont présentées.*

Mots-clés : *Coupe précoce, morphologie des tiges, taux de développement.*

Introduction

Quality (protein and fiber contents) in alfalfa is mainly influenced by leaf to stem ratio. In order to obtain for this ratio a value around 0.85-1.0 (model of the ideal plant, in Rotili *et al*., 1999), we choose to follow different ways: (i) tolerance to early cutting (5% blooming); (ii) modification of stem morphology towards maximum height and shorter internodes; and (iii) uncoupling of growth rate and rate of phenological development. Three plant models have been defined for the different approaches to vigour and quality improvement.

Materials and methods

Tolerance to early cutting

Four populations – Equipe, Victoria (semi-dormant), Sewa (non dormant) and Julus (dormant) – grown in boxes-plot 40 cm diameter, 82 cm high (30 plants/plot); density of 254 plants/m^2. Aerial part and roots were analysed under two cutting regimes: early cutting (50% green bud) and normal cutting (50% blooming). On individual plant basis the following traits were measured: dry matter (DM), protein and sugar content of leaves, stems and roots at different phenological stages (Rotili *et al*., 1991).

Stem morphology

Selfed progenies (S_1) of plants from somatic hybridisation *M. sativa falcata* (Téoulé, 1983), provided by Y. Demarly (Université de Paris) and P. Guy (INRA Lusignan), were crossed, with reciprocals, to non inbred *M. sativa* individuals of different origins. Hybrid progenies (13 *M. sativa* somatic fusion and 2 *M. sativa* s*ativa*) were evaluated for the main stem height and diameter, number and length of the internodes, in two cycles. Chosen individuals were selfed and the same selection procedures were applied to selfed progenies.

Uncoupling growth and development rate

The material used in this study was represented by experimental synthetics with two partly inbred (S_2) components ($2S_2Syn2$) and double hybrids with 4 partly inbred (S_2) components (S_2DHF_1). Within these families (60-90 plants/family) selection was applied for stem height and earliness in the second cut of the first productive year. Individuals with high vigour, maximum stem height and green bud stage were intercrossed to produce an experimental synthetic. This late synthetic is currently grown in PVC tubes 5 cm diameter, 80 cm high (100 plants; one plant/tube), density of 500 plants/m^2, with a second experimental synthetic originated from non dormant varieties.

All the trials were located at Lodi, under a shed, with not limiting irrigation.

Results and discussion

Tolerance to early cutting

Tolerance to early cutting, in term of mortality after 6-7 cuts, is indicated in Table 1 (Rotili *et al*., 1991). The tolerance is a function of the aerial part to root ratio; in non dormant material, as the Egyptian population Sewa, this ratio is clearly shifted towards aerial production. Cv. Equipe, selected at Lodi Institute for the resistance to early cutting, showed the lowest mortality.

Table 1. Mortality (%) in alfalfa populations under early and normal cutting regime

Populations	Mortality (%)	
	50% green bud 7 cuts	50% flowering 6 cuts
Sewa	35	10
Julus	28	16
Victoria	20	7
Equipe	7	2

Stem morphology

The ideal stem morphology for yield and quality should be constituted by a high number of short and regular internodes, thus optimising leaf to stem ratio. Such a stem morphology was described in some somatic hybrids between alfalfa and other species of genus *Medicago* (Arcioni *et al*., 1994). We used plants derived from somatic hybridisation *M. sativa* *falcata* showing short and regular internodes associated to prostrate growing habit and important branching from the basal internodes. These plants were reciprocally crossed with *M. sativa* individuals and selection was applied among and within hybrid progenies for stem height and diameter and total internode number and length. No hybrids *M. sativa* somatic fusion significantly differed from *M. sativa* *sativa* hybrids for average internode length, while some hybrids showed stems significantly shorter and of lower diameter (Table 2); no significant effect of reciprocals was found. It is worthwhile to note that the individual with the minimum internode length (4.80 cm) had a stem height of 80.0 cm and a stem diameter of 2.70 mm. Within progeny phenotypic correlation between average internode length and stem height ranged from 0.34 to 0.66, with an average value of r = 0.53, in *M. sativa* somatic fusion hybrids. Such a low values of r indicate the possibility of selecting for shorter internode length together with important stem height.

The main features of the selected individuals within hybrid progenies (120 plants, representing about 8% of the total hybrid population) are indicated in Table 3.

Two generations of selfing with among and within population selection for high stems and short internode length were applied; S_2 generation is currently on study.

Table 2. Comparison of *M. sativa* somatic fusion and *M. sativa sativa* hybrids for average internode length, stem height (cm) and diameter (mm) at the first productive cycle. Average of 100 plants/progeny

	M. sativa somatic fusion			*M. sativa sativa*
	Mean	Min	Max	Mean
Internode length	6.47	4.80	7.21	6.53
Stem height	75.97			79.55
Stem diameter	2.32			2.76

Table 3. Average internode length, stem height (cm) and diameter (mm) of the selected individuals within hybrid progenies. Average of 120 plants

Internode length	Stem height	Stem diameter
4.97	86.47	2.87

Uncoupling growth and development rate

The synthetic made from materials selected for high vigour, stem height and late development and the non dormant vigorous tester was sown in September 2000. Only data from growth rate (internode number on the main stem and shoot number) one month after sowing are presently available. As expected, non dormant synthetic showed significant higher and more uniform growth rate than the "late" synthetic. Growth rate, dry matter production, stem height and number, earliness will be scored along the first productive year 2001 on a single plant basis.

Conclusions

Three different approaches were used to study the improvement of vigour and quality in alfalfa plants: (i) tolerance to early cutting; (ii) modification of stem morphology; and (iii) uncoupling growth and development rate. Tolerance to early cutting approach has already produced improved materials (cvs. Equipe and Lodi); the other approaches are currently in use in breeding programs at Lodi Institute. As for stem morphology, it is to underline the use of material from somatic hybridisation to increase natural variation for internode number and length that was too narrow to be of a practical interest.

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